MANUAL OF METHODS IN FISHERIES BIOLOGY

compiled by

T. LAEVASTU

Fascicule 2

Section 1. Planning, recording and reporting field work

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
ROME 1965

Printed in Italy

CONTENTS

SECTION 1. PLANNING, RECORDING AND REPORTING FIELD WORK

1.0 INTRODUCTION

The purpose of this manual is to guide those engaged in fisheries research in planning, carrying out, and recording their field work. It is intended primarily for beginners and junior workers, but, since it is a compendium of techniques, forms and tables, it may prove useful also to experienced workers.

The bulk of the book consists of description of techniques of observation and measurement to be carried out during expeditions. The techniques selected are those in most common use for their purpose, and each is described in detail sufficient to enable a worker to use it consistently and reliably.

An often overlooked aspect of this work is the importance of care in keeping records of operations. It is scarcely possible to give too much emphasis to the importance of recording each operation and its results as the work progresses; and these records must be made in a way to permit of effective and economic treatment of them later not only by the observer, but also by others. Much information is lost because sets of data or material are ambiguously identified and because the circumstances under which they have been obtained are incompletely recorded.

1.0.1 Selection and standardization of techniques

In designing or choosing a technique, thought must be given to the following elements:

a purpose for the measurement or observation (that is, a use for the data to be obtained);

which particular physical property to measure or observe;

which equipment is most suitable for the measurement or observation in question, with special regard to the precision obtainable with them;

the manner of manipulation of the equipment in taking the measurement;

the units and forms for recording the measurements and/or observations;

the place, time and frequency of the measurements and/or observations;

the cost per measurement, in time or in money, in relation to the expected results.

Let us treat an example in this way and take length measurement of fish for this purpose.

The purpose of measuring the length of fish in fisheries biology is to ascertain the length composition of the stocks being studied and, by manipulation of the data, the growth rate and other characteristics of these stocks. Continuation of such operations, accompanied by environmental studies permit the research worker to ascertain the influence of the environment on these characteristics and their response to changes in environmental influences.

The physical property to be measured may be the total length of the fish, its standard length, or some other dimension that will reliably represent the size of each fish. The choice of dimension is subject to a number of considerations. Between a number of over-all lengths we must judge which permits the most accurate and consistent results with greatest ease and speed; total length might be easier to measure than length to caudal fork, or than length to caudal base, but for a particular species it might be that measurement of total length (that is, from snout tip to tip of tail at greatest extension) might be unreliable because of frequent damage to tail tip, or might be slow because of the difficulty of getting consistent extension of the caudal fluke.

The shape of the fish might make measurement difficult. It may be, in some species, that a difference between the rate of growth along a normal axis and that along other dimensions might make measurement along the normal axis less informative than measurement along another. Again, the fish may have been partially butchered, so that measurement of total length is not possible; in such cases resort may be made to measurement of some partial dimension and the relation of the chosen dimension with total length should be ascertained.

By this time the main characteristics of the equipment will have been fixed by the choice of the measurement to be made, but further decisions must be made as to the total units in which to measure and the precision to be obtained. A choice must be made between metric or other system of units.

The circumstances under which fish are to be measured may play a considerable part in determining what can be attempted. On the deck of a fishing vessel and on market floors, the need to get the fish quickly stowed away or dispatched to buyers is generally so great that only the simplest operations can be undertaken. Often, in such cases, the measurer will take only length measurements from as large a sample as time permits (subject to sampling rules), and will take a subsample, of fewer fish, on which to make more detailed measurements. In these cases simpler techniques of measurement may be used; for example, the length may be recorded simply as holes in a celluloid strip. When such simple equipment is used the identity of individual measurements is lost at once and the result is simply, and immediately, a length-frequency tabulation; this contrasts with the result of more

detailed measuring, where each fish is represented by the results of various measurements and observations, say of total length, body proportions, sex, gonad condition, stomach contents, and so forth. Of course, where such other measurements are made, the purposes of the work are broader than those stated at the beginning of this exercise.

It is worthwhile to consider what standardization means in this work. Choice must be made of equipment, manipulations and degree of precision, and it is here that the major part of standardization is effected. Statistical methods can be used in comparing results obtained from the use of different types of equipment and different sets of manipulation; these comparisons may be referred to the desired degree of precision. These statistical tests will evaluate each item of equipment and each method.

By standardizing in this way we should be able to ensure that if a particular instance of a particular physical property were to be measured by a group of workers their results would differ only by unavoidable error; and that all data from several separate research programs measuring a particular physical property could be treated as though they were the result of the work of a single person or team. However, the differing circumstances under which research in fisheries biology must be carried out demand relaxation of the more strict rules of a standard. Nevertheless, if a standard has been agreed upon for any procedure, departures from the standard should be clearly shown in accounts of the use of the procedure.

1.1 PLANNING OF RESEARCH AND EXPEDITIONS

Much of the success of an expedition depends upon careful planning before the field work starts. Such planning saves time and money, and ensures that no essential measurements and observations are overlooked. Usually there should be a precruise conference with the staff, after which the final plans are made by the field-party chief, or the scientist in charge.

Whether planning field trips or cruises, the following points should be borne in mind:

1. *The objectives.* To establish these it is necessary to know:

(*a*) What information is required and how it is to be applied. For example, whether it is purely scientific, to widen knowledge, or is for the improvement of some specific aspects of the fisheries industry.

(*b*) How to obtain information in the easiest and most reliable way, and therefore what observations or measurements must be made, and which are the other factors and elements related to the investigation.

(*c*) How the results are to be presented.

2. *Prior information.* All previous information on the special matter under investigation should be studied. If there is none available, the investi-

gator should familiarize himself with the information dealing with closely related subjects or areas. Furthermore, it should be ascertained whether there are data on observations or material in the laboratory or at the base, which have not been worked on, and if this material is complete or not. By doing all this, duplication of previous work is avoided and the investigator profits from past experiences.

3. *The time and money available* for the trip and for studying the collected data. Only such data or material should be collected as are necessary to solve specific problems and can be worked on in a reasonable time in the laboratory or base. The efficiency and experience of observers must also be considered, especially when choosing the personnel.

4. *Choice of instruments.* This depends on what is available and on the investigations that have to be conducted. This matter is discussed in greater detail in the following subsections. The handling of instruments is described in Sections 2 to 5.

1.1.1 Types of operations

The operations in fisheries can be grouped by their purpose as follows:

1. *Reconnaissance.* General study of an area to obtain a picture of its main characteristics.

2. *Exploratory fishing.* Use of various types of fish-searching equipment and fishing gear to ascertain the kinds of fish present in an area and to obtain some idea of the magnitude of the stocks of these. Information would also be obtained on such things as nature of bottom, and sea conditions, that might affect fishing.

3. *Prospecting.* Use, in a particular area, of fish-searching equipment and fishing gear appropriate to one or more species known to be present in the area, to obtain a detailed picture of the distribution of these species and estimates of the magnitude of the stocks.

4. *Experimental fishing.* Use of fishing gear to determine the properties of the gear itself, or of the entire unit of which the gear is part, especially with regard to its effect on the fish stocks. Comparative fishing experiments are probably the most well-known examples of such operations. Experiments to determine the gear most useful in a particular area, or for a particular species or group of species, are included here.

5. "*Census*" *and routine operations.* Regular field work, in markets, at landing places and on fishing grounds, in sampling fish catches and stocks, to ascertain certain characteristics of the populations under exploitation, such as age, size and sex composition, growth rate, reproduction and recruitment, and mortality.

6. *Analytical operations.* Bioanalytical work such as tagging, special sampling of noncommercial stocks (eggs, larvae, young fish, fish food), and research in fundamental biology (e.g. behavior and physiology), to ascertain characteristics of the stocks and their environment not revealed by any of the preceding operations or by analysis of data on commercial fishing operations.

It will be observed that in the above list each type of operation is defined in terms of objectives and equipment. The foregoing are primary operations for fisheries biology; each is generally accompanied by complementary operations, that is, work in meteorology, oceanography or limnology.

Commercial fishing operations as such are included in the above list only in category 5 where the research operation draws its material by sampling of commercial catches.

It must be kept in mind that in looking at the work in this way we are not suggesting that the complementary operations are of less value or importance than the primary. In fact, the complementary operations of the programs with which this book deals are the entire operations of other programs. However, in this program, the specification of the environment is secondary to the work directly on the fish stocks, even if a specification of some degree is essential to most fishery research.

For an institute engaged equally, or almost equally, in fisheries research and in "pure" oceanography or limnology, it presumably is necessary to decide which type of program on each occasion will have prior claim on the operational plan of the expedition. If fisheries have prior claim, the plan would be developed as described here, with the oceanographic or limnological work carried out either solely as complementary operations, or as complementary operations with additional work as opportunity permitted. If oceanography or limnology have priority, then fisheries work would be carried out as opportunity offered. Any conflict between technological research and research in fisheries biology would be similarly resolved.

1.1.2 **Operational plan**

An operational plan is a statement of: (1) operations to be performed and techniques to be used; (2) itinerary to be followed and stations to be occupied; (3) operational routine to be followed at each station.

There are two main types of field expeditions, each needing different planning:

1. (*a*) Trips on shore; (*b*) in small boats, close to the shore and of less than 24 hours duration; (*c*) observations on commercial fishing vessels. Trips of this sort are usually made by one or two men.

2. Cruises in research vessels of more than 24 hours duration.

1.1.2.1 Trips on shore

Shore trips are usually made for the following purposes:

(*a*) Reconnaissance survey of fisheries conditions (catch, gear, economics) in various villages and harbors and for interviewing fishermen. (*b*) Sampling and/or inspecting of commercial catch. (*c*) Investigation of beaches for various purposes.

The points to observe when planning for this kind of trip are:

(*a*) Transportation.

(*b*) Equipment. This depends on the kind of work to be done and on the means of transportation. Most laboratories usually have specially designed transportable field kits for trips on shore and in small boats. A fisheries biologist should always carry with him on such trips the following simple equipment:

1 pocket set of dissecting instruments
1 tape measure (meter)
1 magnifying glass
1 diary and pencils
1 pocket spring balance
1 sea chart of the area
1 small portable thermometer
1 camera

1.1.2.2 Trips in small boats close to the shore

The planning of these trips again depends on factors peculiar to the locality and laboratory and on the type of work to be done and the information to be collected. Usually trips of this sort are made from the laboratory or fishing harbor as the base, for the following purposes:

1. Collection of animals or water samples for laboratory studies.
2. To test instruments.
3. Local plankton and benthos studies (e.g., investigation of seasonal variations).
4. Local station hydrographic studies, such as tides and sea water sampling.
5. Coastal pollution studies.
6. Experiments with small fishing gear, such as long lines, trolls, gill nets, traps, beach seines.

The planning also depends on the size and seaworthiness of the boat, and

on the duration and distance from the shore. The following should be considered:

1. Weather situation and forecast.
2. The instruments suitable for use, and methods to secure them in small boats.

Small diary logs are generally used on these trips. However, if fishing and plankton work is to be done, the general fishing log and the plankton log should be used (see Section 1.2).

1.1.2.3 Observations on commercial fishing vessels

Observations made on commercial fishing vessels are usually to:

1. Sample the commercial catch.
2. Observe the behavior of gear.
3. Make simple notes on the environment as it affects commercial fishing.
4. Note the fishing conditions.
5. Carry out special sampling which does not interfere with commercial operations, such as underway plankton sampling, bottom sampling and echo sounding.
6. Instruct and assist fishermen in using new gear, locating fish, etc.

When planning these trips the observer must know the plans of the commercial fisherman and adjust his activities accordingly. The observer can usually take a certain number of instruments, and partly complete the cruise and station logs, the meteorology data sheet, and the fishing log.

It is of value when fishermen are interviewed on these trips to ascertain from them why they fish on a particular ground, their special observations on fish and gear behavior, their knowledge of average fishing and environmental conditions, and other matters bearing on the fishing operations.

1.1.2.4 Cruises in research vessels

After the field-party chief has made up a cruise plan in co-operation with the ship's master, the plan should be approved by the head of the institution.

The field-party chief is responsible for any eventual modifications of the plan if the conditions so require. He also assigns scientific and technical staff to their duties.

The master is responsible for provisioning, fueling and preparing the vessel. In general, the small space in a shipboard laboratory and on deck must be carefully planned for every trip to suit the work which it is intended to do.

The field-party chief also prepares the sailing order (usually three copies - office, master, cruise file). The sailing order contains the following information:

1. Departure date.
2. Approximate date of return.
3. Approximate sailing route.
4. Description of work to be done.
5. Operational schedule.
6. Personnel list.

In addition, the following information can be included:

7. List of gear.
8. Records and reports to be filled.
9. Special instructions.

To obtain the fullest information from the cruise, planning must continue during the cruise, especially when the original plans have to be modified according to the data obtained and other conditions.

1.1.3 Pattern of observations

A station is a geographically identifiable point at which operations are carried out, or from which certain operations (e.g., net hauling) are begun on a single occasion. If a particular point is returned to for repetition of operations, or for a new set of them, it is to be regarded as a new station unless a set of stations has been selected in special pattern and each is returned to a number of times. In this case serial identification must be used within the station identification. The position of each station actually occupied should be ascertained carefully and recorded in the log of the expedition. The stations to be occupied during an expedition may be fixed in definite pattern beforehand on the basis of evidence on the distribution of some feature, e.g., of salinity, current, or some organism that is regarded as an ecological indicator. Alternatively, the stations may be decided upon during the expedition as conditions permit and as contemporary observations suggest.

The following suggestions are often useful to determine the pattern of stations.

1. The section of stations should usually cross the isolines of environmental or biological distribution of properties.
2. The distance between the stations depends on the magnitude of change of the properties within this distance which are to be measured.

3. The frequency of sampling in routine stations depends on the rate of change of properties with time.

4. Hydrographical stations and/or other observations of the environment should be made where biological sampling is done or experimental fishing conducted.

5. All work which can be done before reaching the station, such as fixing thermometers, preparing log sheets, checking bottles, etc. should be done while underway.

6. Previous experiences and information should be used to form the sampling patterns.

In an expedition plan the operational plan is a set of instructions to the technical (scientific) staff of the expedition, and should be explicit as to what is to be done, where and when, and what modifications of the plan may be made.

The operational plan stands as part of the expedition plan, as in the following framework.

Expedition plan

Expedition number (cruise, field trip or visit)

to (area, locality or position)

Planned duration: commencing ending

Objectives:

Staff:

Equipment:

- Vessel
- Fish searching gear
- Fishing gear
- Meteorological equipment
- Hydrographical equipment
- Biological equipment

Operational plan:

- Operations to be conducted
- Itinerary
- Station list (or plan) and operational routines

Records:

1.1.4 Lake, stream and river basin surveys with respect to fisheries

1.1.4.1 Purposes of inland fisheries surveys

The purpose of a limnological and fisheries survey is to ascertain with a minimum expenditure of time and money the essential physical, chemical and biological characteristics of a body of water. On the basis of this information critical studies in limnology and fisheries can be instituted, or a fish management program can in some instances be undertaken immediately.

Having attained the scheduled information, the survey provides the factual basis for:

(*a*) establishment (or reorientation) of policy or program, and

(*b*) formulation of a program of management or developmental action, which, with respect to fisheries, is designed to increase production or improve the efficiency of fishing operations. (There are, of course, instances where preservation rather than increased production may be all that is possible.)

It must also be emphasized that the short-term survey rarely permits an adequate evaluation of the size or composition of the fish population or of the harvest. While certain attributes of the population can be determined by rapid sampling, detailed knowledge of the dynamics of fish populations and the other biota depend upon the employment of studies of such complexity or duration that they fall outside the terms of reference of most surveys.

One can sum this up by saying that the amount of time and effort that can be expended and the methods to be employed are largely functions of the purposes to be attained and the ever-prevailing factors of economy and administrative pressure.

It is obvious, therefore, that it is impossible to construct an ideal or universal plan or outline which will be applicable for a survey of any type of lake in any part of the world or which can meet either the demands for a very short survey or the desires (of many scientists) for very long-range studies. In short, one cannot meet the needs of all workers and, for that matter, it is not within the capabilities of all workers to perform the type of work that might ideally be contemplated.

It is possible, however, to present an outline, general in nature, but with considerable detail, which can:

(*a*) provide a guide to (or checklist of) the types of information that might be secured for such a survey, and

(*b*) function as an outline which can be used in organizing a report which presents the information secured and enables one to draw conclusions and make recommendations.

Additions or deletions can be made, depending upon the scope, kind and needs of the project. For a very rapid survey, only a little of this information need be collected: indeed, probably only a little of it can be obtained. On the other hand, those making a long and intensive study may borrow heavily from the suggested material.

A certain amount of repetition in the headings or items of information is purposeful. It merely indicates that there are multiple ways of presenting or discussing the same data, and obviously, each author will have his own opinion as to the best placement for his purposes.

It may also be noted that it is usually most convenient to record much of the original data on specially designed lake survey forms or field sheets. The data can then be stored on these same sheets or can be transferred to other forms for filing or can be used as the bases for a more extended report. The outline may be useful in designing such forms.

For purposes of study, especially in the case of long streams, it is usually convenient, and often necessary, to divide the stream into sections and treat each section more or less as an individual unit. The boundaries of the sections should be selected on the basis of ecological and political considerations, and, where possible, with a view toward the eventual designation of the sections as management units.

While each section can be described separately, more or less according to the suggestions given in the outline it is, of course, also necessary to consider and describe the stream as a whole.

1.1.4.2 Outline for a lake survey

Abstract (A brief abstract of the report should be given here)

1. Introduction

   1.1 Purpose of the survey
   1.2 Background material (previous surveys, etc.)

2. Acknowledgments

3. Account of the present survey

   3.1 Agencies concerned
   3.2 Personnel and leadership
   3.3 Time and duration (chronological account)
   3.4 Sources of data
   3.5 Methods

      3.51 List of stations
      3.52 Collecting methods
      3.53 Sampling program
      3.54 Analytical methods
      3.55 Treatment of data
      3.56 Storage of data

4. General description of the lake and its basin

   4.1 Name of lake (including synonyms)

4.2 Location, accessibility, ownership, use

4.21 Geographical designation
4.22 Elevation (altitude)
4.23 Roads, trails, railroads, airports or landing strips
4.24 Distances from major points
4.25 Boat landings, ports, fishing harbors
4.26 Name of owner or controller of accessibility and fishing
4.27 Uses of the lake (fishing, recreational, irrigation, etc.)

4.3 History of the lake with particular respect to its fishing
4.4 Geological history
4.5 Drainage basin

4.51 Area
4.52 Topography
4.53 Basic rocks and soil
4.54 Vegetational cover
4.55 Climatic conditions

4.551 Air temperature
4.552 Precipitation
4.553 Evaporative rate
4.554 Humidity
4.555 Wind
4.556 Air pressure
4.557 Sunshine

4.56 Drainage affinities and lake origin
4.57 Watershed use and degree of development (industrialization, urbanization, etc.)
4.58 Inlets

4.581 Length
4.582 Widths
4.583 Depths
4.584 Bottom type
4.585 Flow (in m^3)
4.586 Water temperatures
4.587 Stream gradient or slope
4.588 Barriers to fish migration
4.589 Relationship to lake fishery
4.5899 Etc.

4.59 Outlets

(As for Inlets)

5. Physical character of the lake (nature of the physical environment)

5.1 Morphometry (based on a bathymetric map showing soundings and to scale)

5.11 Length

- 5.12 Breadth
- 5.13 Depths (maximum, mean, relative)
- 5.14 Area, surface
- 5.15 Area, subsurface (within isobaths)
- 5.16 Shoreline length
- 5.17 Shoreline, development of
- 5.18 Basin slope (between isobaths and mean slope) and profiles
- 5.19 Volume
    - 5.191 Volume, development of
    - 5.192 Rates of change of area with respect to volume

5.2 Morphology

- 5.21 Shape
- 5.22 Insulosity
- 5.23 Shore processes
    - 5.231 Cliff, beach, littoral shelf
    - 5.232 Spits, bars
    - 5.233 Bays
    - 5.234 Deltas
- 5.24 Sublacustrine elements
    - 5.241 Shelves
    - 5.242 Depressions
    - 5.243 Channels

5.3 Wind: velocity, direction, duration

5.4 Thermal properties

- 5.41 Water temperatures
    - 5.411 Surface
    - 5.412 Subsurface
- 5.42 Stratification and turnover
- 5.43 Heat budget
- 5.44 Ice conditions

5.5 Hydromechanics (water movement)

- 5.51 Currents: velocity and direction
- 5.52 Density currents
- 5.53 Fluctuation in level
- 5.54 Seiches
- 5.55 Tides

5.6 Color (true color)

5.7 Light penetration (as determined by limit of visibility tests [Secchi] or light measurement [photometer])

5.8 Turbidity (as determined by silica standard, platinum-wire method, turbidimetric methods)

5.9 Bottom materials

- 5.91 Types
- 5.92 Extent

6. Chemical character of the lake (nature of the chemical environment)

- 6.1 General hydrochemistry
  - 6.11 Hydrogen-ion concentration (pH)
  - 6.12 Alkalinity
    - 6.121 Methyl-orange (bound CO_2)
    - 6.122 Phenolphthalein
  - 6.13 Total dissolved solids
    - 6.131 Nonvolatile solids (ash content)
    - 6.132 Loss on ignition
  - 6.14 Salinity
  - 6.15 Total hardness
  - 6.16 Specific conductivity
  - 6.17 Redox potential
  - 6.18 Biochemical oxygen demand (BOD)
  - 6.19 Total organic content
  - 6.199 Equilibrium between water and mud
- 6.2 Dissolved gases
  - 6.21 Oxygen
  - 6.22 Carbon dioxide
  - 6.23 Others (methane, hydrogen sulfide, nitrogen, ammonia, sulfur dioxide, carbon monoxide, etc.)
- 6.3 Dissolved (inorganic) solids
  - 6.31 Phosphorous compounds
    - 6.311 Total phosphorus
    - 6.312 Soluble phosphate phosphorus
    - 6.313 Sestonic acid-soluble phosphate phosphorus
    - 6.314 Organic soluble (and colloidal) phosphorus
    - 6.315 Organic sestonic phosphorus
  - 6.32 Nitrogen compounds
    - 6.321 Molecular nitrogen in solution
    - 6.322 Organic nitrogen compounds
    - 6.323 Ammonia as $NH_4 +$ and $NH_4 OH$
    - 6.324 Nitrite
    - 6.325 Nitrate
  - 6.33 Important cations
    - 6.331 Sodium (Na)
    - 6.332 Potassium (K)
    - 6.333 Magnesium (Mg)
    - 6.334 Calcium (Ca)
    - 6.335 Copper (Cu)
    - 6.336 Iron (Fe)
    - 6.337 Zinc (Zn)
    - 6.338 Manganese (Mn)
    - 6.339 Etc.

6.34 Important anions

6.341 Bicarbonate (HCO_3)
6.342 Sulfate (SO_4)
6.343 Chloride (Cl)
6.344 Carbonate (CO_3)
6.345 Silicate (SiO_4)

6.4 Organic compounds

6.41 Organic nitrogen (see 6.3)
6.42 Organic phosphorus (see 6.3)
6.43 Fats (ether extracts)
6.44 Vitamins
6.45 Etc.

6.5 Water pollution

6.51 Source
6.52 Type
6.53 Severity
6.54 Control

7. Biological character of the lake (see also 8, 9 and 10 below)

(The influence of the physical and chemical factors described above may be discussed here or the discussion may be deferred to 14.)

Other points requiring discussion may include:

7.1 Habitat, zones, associations
7.2 Nutrient cycles
7.3 Food chains
7.4 Measurements of basic organic production
7.5 Energy cycles

8. Flora and fauna (exclusive of vertebrates)

[This section may contain:

Lists of species (or other groups)
Records of their abundance (qualitative; quantitative; seasonal)
Records of their distribution (vertical; horizontal; seasonal)]

8.1 Bacteria and fungi
8.2 Plankton (macro-, net-, nanno-, total)

8.21 Phytoplankton
8.22 Zooplankton

8.3 Neuston
8.4 Pleuston
8.5 Nekton (other than fishes, for which see 9)
8.6 Periphyton
8.7 Rooted aquatic vegetation (phytobenthos)

8.71 Marginal (shore)
8.72 Emergent
8.73 Submergent

8.8 Vegetation-inhabiting animals

8.9 Bottom fauna (zoobenthos)

9. Fish fauna

Presentation of the data to be assembled here can follow various patterns, for example:

(*a*) List of species including scientific, and official common names and vernacular names; and/or

(*b*) Species grouped by communities, associations, etc.; i.e., according to:

(i) type of nutrition

(ii) habitat occupied

(iii) etc., and/or

(*c*) Species grouped for purposes of fish management, selecting some combination from categories such as:

Commercial

Sport (game fishes, pan fishes)

Forage

Coarse (rough)

Obnoxious

Desirable

Undesirable, etc., and/or

(*d*) A rather extended treatment can be used for each individual species.

9.1 Name (scientific, common, vernacular)

9.2 Distribution (within the lake)

9.21 Ecological characterization of the area

9.22 Differential distribution

(Areas occupied by eggs, larvae and other junior stages: annual variations in these patterns, and seasonal variations for stages persisting over two or more seasons. Areas occupied by adult stages: seasonal and annual variations of these.)

9.3 Bionomics and life history

9.31 Reproduction

9.311 Maturity (age and size)
9.312 Fecundity
9.313 Spawning (seasons, frequency, time, etc.)
9.314 Spawning grounds

9.32 Larval history

9.33 Adult history
- 9.331 Longevity
- 9.332 Hardiness
- 9.333 Competitors
- 9.334 Predators
- 9.335 Parasites and diseases

9.34 Nutrition and growth
- 9.341 Feeding
- 9.342 Food
- 9.343 Condition
- 9.334 Growth/age

9.35 Behavior
- 9.351 Migration and local movements
- 9.352 Schooling
- 9.353 Reproductive habits

10. Other vertebrates

(A treatment somewhat similar to that used in 9 may be followed. Emphasis should be placed on the relationship of these animals to the fishery.)

11. Fish population studies

11.1 Structure
- 11.11 Sex ratio
- 11.12 Age composition
- 11.13 Size composition

11.2 Size and density
- 11.21 Average size
- 11.22 Changes in size
- 11.23 Average density
- 11.24 Changes in density

11.3 Natality and recruitment
- 11.31 Natality
- 11.32 Natality rates

11.4 Mortality, morbidity
- 11.41 Rates of mortality
- 11.42 Factors or conditions affecting mortality
- 11.43 Factors or conditions affecting morbidity
- 11.44 Relation of morbidity to mortality rates

11.5 Dynamics of population

11.6 Relation of population to community and ecosystem, biological production, etc.

12. Exploitation

12.1 Commercial fishing

12.11 Number of fishermen
12.12 Fishing equipment

12.121 Gear
12.122 Craft

12.13 Fishing areas

12.131 Geographic
12.132 Depth ranges

12.14 Fishing seasons
12.15 Fishing operations and results

12.151 Effort and intensity
12.152 Selectivity
12.153 Catches, landings (statistics)

12.16 Processing
12.17 Distribution
12.18 Marketing
12.19 Licensing or issuance of permits

12.2 Sport fishing

(In making studies of the exploitation of sport [game] fishes, recourse is usually had to a creel census or some other method of sampling.)

12.21 Creel census information

12.211 Fishermen

12.2111 Number
12.2112 Type (classed by age, sex, geographical origin, goal, type of gear used)

12.212 Gear and methods
12.213 Species composition of catch
12.214 Size composition of catch
12.215 Fishing effort or pressure (man-hours, etc., of fishing, fishermen or man-hours per unit surface area, etc.)
12.216 Fishing success (catch per unit of effort: fisherman-day or fisherman-hour, fisherman-season)
12.217 Harvest (total catch in numbers and/or weight; catch per unit surface area, etc.)
12.218 Distribution and characteristics of the fishing (geographical, seasons, time of day, etc.)

(In addition to the above types of information it may also be important to measure the economic value of sport fishing in a lake [or any given area] as expressed in monetary terms. Such economic evaluation involves the collection of various data such as those listed below.)

12.22 Economic value

12.222 Number of fishermen
12.223 Number of days fished
12.224 Expenditures per fisherman per trip or season for:

12.2241 Fishing tackle and other equipment
12.2242 Trip expenditures, transportation, food, lodging, etc.
12.2243 Licenses, permits, leases
12.2244 Other pertinent expenditures

12.3 Subsistence fishing

(List whatever data it appears advisable to collect or which can be collected, using 12.1 and 12.2 above as guides.)

13. Fisheries management and regulations

13.1 Regulations

13.11 Fishing seasons
13.12 Size limits
13.13 Periodic (daily, weekly, seasonal, etc.) limits
13.14 Restrictions on sex, condition, etc.
13.15 Closed or restricted areas
13.16 Gear or craft restrictions

13.2 Control or alteration of physical features of the environment

13.21 Regulation of flow (inlets and outlets)
13.22 Control of water levels
13.23 Control of erosion and silting
13.24 Fishways
13.25 Barrier removal and/or erection
13.26 Fish screens
13.27 Improvement of spawning grounds
13.28 Construction of fish shelters, attractors, etc.
13.29 Improvement of habitat in the inlets or outlets

13.3 Control or alteration of chemical features of the environment

13.31 Pollution control
13.32 Salinity control
13.33 Fertilization

13.4 Control or alteration of the biological features of the environment

13.41 Control of aquatic plants
13.42 Introduction of foods (plant and invertebrate)
13.43 Introduction of forage fish
13.44 Control of disease and parasites
13.45 Control of predation and competition
13.46 Population manipulation

13.5 Artificial stocking and feeding

13.51 Initial introduction

13.52 Maintenance stocking
13.53 Feeding
13.54 Introduction of exotic species
13.6 Other methods and measures

14. Discussion and conclusions

15. Recommendations

16. Literature cited

17. Appendixes (supporting data, maps, photographs, diagrams, tables, special studies, etc.)

1.1.4.3 Outline for a stream survey

Abstract (a brief abstract of the report should be given here)

1. Introduction

   1.1 Purpose of the survey
   1.2 Background material (previous surveys, etc.)

2. Acknowledgments

3. Account of the present survey

   3.1 Agencies concerned
   3.2 Personnel and leadership
   3.3 Time and duration (chronological account)
   3.4 Sources of data
   3.5 Methods

      3.51 Division of the stream into sections
      3.52 List of stations
      3.53 Collecting methods
      3.54 Sampling program
      3.55 Analytical methods
      3.56 Treatment of data
      3.57 Storage of data

4. General description of the stream and its basin

   (Here, or at some other place in the report, it may be advisable to present a brief picture of the entire stream before proceeding with the detailed treatment. This is, perhaps, best accomplished by tracing its course from source to mouth. Major emphasis may be placed on describing its size and type, the physiography, etc.)

4.1 Name of stream (including synonyms)
4.2 Location accessibility, ownership, use

4.21 Political designations (country, state, province, county, district, etc.)
4.22 Geographical designation
4.23 Elevation (altitude) at source, mouth and other points; especially upper and lower ends of each section
4.24 Roads, trails, railroads, airports, landing strips
4.25 Distances from major points
4.26 Boat landings, ports, etc.
4.27 Name of owner(s), controller(s) of accessibility and fishing
4.28 Uses of the stream

4.3 History of the stream with particular respect to its fishery
4.4 Geological history
4.5 Drainage basin

4.51 Area
4.52 Topography
4.53 Basic rocks and soil
4.54 Vegetational cover
4.55 Climatic conditions

4.551 Air temperature
4.552 Precipitation (rain, snow)
4.553 Evaporative rate
4.554 Humidity
4.555 Wind
4.556 Air pressure
4.557 Sunshine

4.56 Tributaries (streams, lakes, etc.)

(To be described briefly as summarized in the outlines or to be made the subject of separate surveys if deserved.)

4.57 Distributaries and related waters (overflow areas, oxbow lakes, etc.)

(As for tributaries or lakes.)

4.58 Watershed use and degree of development (industrial, urbanization, etc.)

5. Physical character of the stream

5.1 Stream measurements

5.11 Length of stream and sections
5.12 Widths (of channel and of water surface itself)
5.13 Depths (of channel and of water)
5.14 Area
5.15 Stream profiles and gradients
5.16 Transverse profiles
5.17 Meander factor
5.18 Variations in water level (low, high, floodwater levels)

5.2 Stream typology

(In characterizing the stream it is useful to describe some of the following.)

5.21 Source of water supply (surface, runoff from rain or snow, springs, groundwater seepage, glaciers, diversions from other waters, return irrigation water, etc.)
5.22 Fluvial stage, physiographically
5.23 Stream margins or banks (type, height, composition, cover, vegetation, shade, etc.)
5.24 Stream components (pools, flats, runs, riffles, rapids, stickles, cascades, etc.), especially their number, size and relative frequency
5.25 Type of flow and velocity
5.251 Whether smooth, broken, cascading, turbulent, etc.; or permanent, intermittent
5.252 Velocity of current
5.253 Tides (as in estuaries)
5.254 Time lags

5.3 Stream bed (bottom) materials

5.31 Types
5.32 Extent
5.33 Use or suitability as spawning grounds

5.4 Rate of flow and volume

5.41 Rate of flow (m^3 sec^{-1}) (extremes and means; seasonal, diurnal and nocturnal fluctuations)
5.42 Volume or runoff (within a given time interval; extremes and means; as measured in acre-feet, milliards, etc.)

5.5 Thermal properties

5.51 Water temperatures
5.52 Thermal gradient
5.53 Snow and ice conditions

5.6 Color and light penetration
5.7 Turbidity
5.8 Barriers and deterrents (to fish migration)
5.9 Diversions

6. Chemical character of the stream

(See the outline for a lake survey and select appropriate items. Usually one does not make as detailed chemical analyses of streams as of lakes unless some special circumstances prevail.)

7. Biological characteristics of the stream

(The influence of the physical and chemical factors described above in determining the biological conditions of the stream [growing conditions,

food production, suitability for spawning, etc.] may be discussed here, or referred to 14.)

8. Flora and fauna (exclusive of vertebrates)
   (See the outline for a lake survey; select appropriate items or modify as necessary. The terrestrial fauna [primarily insects] also deserve consideration as fish foods.)

9. Fish fauna
   (See the outline for a lake survey; select appropriate items or modify as necessary.)

10. Other vertebrates
    (See the outline for a lake survey.)

11. Fish population studies
    (See the outline for a lake survey.)

12. Exploitation
    (See the outline for a lake survey; select appropriate items and modify as necessary.)

13. Fisheries management and regulations
    (See the outline for a lake survey; select appropriate items.)

14. Discussion and conclusions

15. Recommendations

16. Literature cited

17. Appendixes (supporting data, maps, photographs, diagrams, tables, special studies, etc.)

1.1.4.4 Outline for a river basin survey

Abstract (a brief abstract of the report should be given here)

1. Introduction
   - 1.1 Purpose of the survey
   - 1.2 Background material
     - 1.21 Brief description of water and land use within the basin and the agencies concerned
       - 1.211 Past

1.212 Present
1.213 Projected

(This should include statements of the general effect of these uses with respect to the fishery and a detailed history of the applications or steps taken to undertake such development.)

1.22 Previous surveys with respect to fisheries

2. Acknowledgments

3. Account of the present survey
   3.1 Agencies concerned
   3.2 Personnel and leadership
   3.3 Time and duration (chronological account)
   3.4 Area covered; itinerary
   3.5 Sources of data
   3.6 Methods
      3.61 Division of the area for coverage
      3.62 List of stations
      3.63 Collecting methods
      3.64 Sampling program
      3.65 Analytical methods
      3.66 Treatment of data
      3.67 Storage of data

4. Description of area affected
   4.1 General description of drainage basin

   (See 4 of the outline for a stream survey and select appropriate items.)

   4.2 Description of the stream(s) and/or lake(s) affected

   (See 5, 6, 7 and 8 of the outlines for stream surveys and lake surveys and select appropriate items.)

5. Description of the fishery and its management

(Again, the stream and lake outlines, 9, 11, 12 and 13, can be used as guides.)

Emphasis should be placed on describing:

1. All facts concerning the bionomics and life history of the species involved which are of pertinence with respect to evaluating the effect of the proposed river basin development upon the stocks.

2. The productivity of the stream as measured in units of fish
   (*a*) Past
   (*b*) Present
   (*c*) Potential (as under improved management or changed natural conditions)

3. Economic value of the resource as measured in various ways

(*a*) Commercial catch

(i) Number and/or weight of fish
(ii) Price paid to fishermen
(iii) Wholesale value of the product
(iv) Retail value of the product
(v) "Profits" made at various producer and distributor levels
(vi) Etc.

(*b*) Sport catch

(i) Number and/or weight of fish
(ii) Value as determined by assigning a monetary value to each unit taken
(iii) Value based on expenditures incurred in angling
(iv) Etc.

(*c*) Subsistence catch

(i) As in (*b*) above
(ii) As in (*b*) above
(iii) Etc.

4. Other values

(*a*) Nutritional (e.g., in terms of protein)

(i) to man
(ii) to wildlife

(*b*) Recreational

(*c*) Scientific

(*d*) Aesthetic

6. Proposed developments [1]

(This may begin with an introductory statement as to the purpose and scope of the project as a whole, to be followed by a description of the individual components of the project, i.e., each dam, diversion, reservoir, etc., using the outlines given below.)

6.1 Dams

6.11 Name
6.12 Location
6.13 Ownership and controlling agency (if different)
6.14 Age (dates: construction started, construction completed, storage commenced, lake first filled; dam first became a barrier to fish migration; initial operation; etc.) [2]

---

[1] This portion of the outline can, of course, be used to describe existing development.
[2] For projected dams, use scheduled or anticipated dates.

6.15 Use (irrigation, hydroelectric power, water power, flood control, domestic supply, industrial supply, compensation, percolation, stream-flow maintenance, fishing, recreation, salinity control, debris control, etc.)

6.16 Description

6.161 Type

6.162 Dimensions and elevations

6.1621 Height and elevations (at stream bed, crest, spillway crest, etc.)

6.1622 Length of crest

6.1623 Thickness (at crest, at base)

6.163 Slopes (horizontal to unit vertical on downstream and upstream sides)

6.164 Facings and apron (downstream and upstream)

6.165 Foundation formation

6.166 Spillway

6.1661 Discharge (maximum capacity, minimum expected)

6.1662 Controls (type, number and description; radial gates, drumgates, flashboards, etc.)

6.17 Outlets (see also 6.18 and 6.3)

6.171 Type and use of water (canals, tunnels, sluice gates, penstocks, river outlets, "fish water" outlets, special outlets as for fishways, fish flumes, etc.)

6.172 Dimensions and elevations

6.173 Discharge (maximum capacity, minimum expected)

6.174 Controls (type, number and description)

6.175 Fish screens or deflectors (mechanical, electrical, etc.) (Describe fully location, type, dimensions, size of mesh or bars, type of cleaners, bypasses, etc.)

6.176 Special devices (other than screens) used for fish protection or fish passing downstream

6.18 Operation schedule of dam and outlets

6.181 Periods and amounts of discharge

6.2 Fishways, fish locks, fish lifts, etc.

(Describe fully: location, type, dimensions, elevations, collection systems, operation schedule, counting facilities, etc.)

6.3 Diversions or conduits

6.31 Name

6.32 Location and route

6.33 Ownership and controlling agency (if different)

6.34 Age (dates of construction, initial operation)

6.35 Use (see 6.15)

6.36 Headworks or intake

6.361 Controls

6.362 Fish screens or deflectors
6.363 Special features (desilting, etc.)
6.364 Operation schedule

6.37 Description of conduit itself

6.371 Type (canal, tunnel, etc.)
6.372 Dimensions (length, width, depth, side slopes)
6.373 Bottom, facings, linings, etc.
6.374 Capacity (maximum, normal discharge, minimum expected)
6.375 Gradients
6.376 Current velocity
6.377 Drops, checks or barriers en route

6.38 Connections with other waters (including spill): bypasses, pumps, drainage canals, etc.

6.39 Fishing

6.391 Amount of fishing water
6.392 Details of fishery
6.393 Effect of operations (weed control, dredging, desilting, drainage, etc., on fishery)

6.4 Power plants

6.41 Name
6.42 Location
6.43 Ownership and controlling agency (if different)
6.44 Age (dates: of construction, of initial operation, etc.)
6.45 Use
6.46 Description

6.461 Head
6.462 Penstocks (capacity or rate of flow)
6.463 Turbines (number, type, clearances, depth setting, etc.)
6.464 Operating capacity (Kw, HP)

6.47 Forebays
6.48 Afterbays and/or tailwaters
6.49 Future developments

6.5 Reservoirs

(The outline for a lake survey can be used as a guide to the description of a reservoir, existing or projected.)

Since reservoirs, in general, fluctuate to a much higher degree than do natural lakes, special attention should be paid to: outlining the fluctuation schedule; describing the morphometry, morphology, thermal properties, hydromechanics, etc., at different water levels; determining the effect of such changes on the biological character of the lake and its fishery.

Aside from the items already enumerated in the lake outline it may be useful to consider:

(i) Preparation of the terrain before flooding

(ii) Provision for dead storage
(iii) Possibility of draining the reservoir
(iv) Expected sedimentation rate

6.6 Other types of land and water use developments that have a direct or immediate effect upon the watercourses

(Describe all of these in sufficient detail so that the effect on the fishery can be evaluated.)

6.61 Drainage works
6.62 Dredging
6.63 Stream-course alteration
6.64 Leveeing, diking, construction of flood walls, etc.
6.65 Aquatic vegetation control
6.66 Spoil deposition
6.67 Lowering of natural lake levels
6.68 Changes in streams due to road construction (culverts, channel construction, etc.)
6.69 Etc.

6.7 Other developments or changes resulting from development

(Here one might discuss the planned developments [or the changes that will occur as a result of the initial development] in land and water use which may also have an effect on the fishery.) [3]

Among these may be listed the changes or developments in:

(i) Hunting (for subsistence)
(ii) Grazing
(iii) Agriculture
(iv) Forestry
(v) Mining
(vi) Soil conservation
(vii) Environmental sanitation
(viii) Travel and transportation
(ix) Industrialization
(x) Urbanization
(xi) Recreation
(xii) Changes in (human) population (growth or decline, resettlement, etc.)

7. Effect of proposed (and/or existing) developments on the fishery

(Here one should list and describe the effects that any of the structures or

---

[3] As outlined, the distinctions between 6.6 and 6.7 are somewhat arbitrary. The developments listed under 6.7 may, perhaps, be said to act only indirectly on the watercourses and hence on the fishery. Nevertheless the effect of some of these developments or practices on the aquatic resources may be of the greatest importance.

operations discussed in 6 have on the environment and the fishery. Some of the possible effects are listed below as a guide.)

7.1 Dams

7.11 May constitute physical barriers or deterrents to fish migration [4]

7.111 Upstream

7.112 Downstream

7.12 May cause physical injury to or result in death to fish falling over the spillway

7.13 May drown out the present stream fishery above the dam

7.14 May create new and enlarged fishing areas (reservoirs) (see 7.5)

7.15 By altering the magnitude and chronology of the flows below them, they may:

7.151 Reduce or increase the space available for fish and/or the fishing area

7.152 Reduce or increase the size and/or quality of spawning and nursery grounds, or withhold access to them

7.153 Reduce or increase the food-producing areas or change their components

7.154 Produce changes in water temperature

7.155 Produce changes in water chemistry

7.156 Produce changes in water turbidity

7.157 Change the capacity of the stream for self-purification

7.2 Diversions or conduits may:

7.21 Result in loss of fish which enter them

7.22 Result in the creation of additional aquatic habitat and fishing areas

7.23 Result in the introduction of aquatic organisms into drainage basins where they did not formerly reside

7.3 Other appurtenances or devices connected with dams, desilting devices, for example, may harm fish which enter them

7.4 Power plants

7.41 Damage to upstream migrants may occur if they enter the draft tubes of power plants and find their way into the turbines

7.5 Reservoirs

7.51 May possess an area and volume of water with a more productive capacity than the original stream area, albeit usually for a different fauna

7.52 Changes in water level may: result in the stranding of fish, affect food production, affect spawning and spawning areas, permit undesirable fish to ascend into waters where they were not resident, etc.

---

[4] Although their effect as deterrents is almost always unfavorable, in some cases they may act as barriers to undesirable fishes which could otherwise invade productive upstream areas.

7.6 Other types of development having a direct or immediate effect on water courses and (thereby) on the fishery

(Describe the effects of the developments listed in 6.6.)

7.7 Other types of development or changes resulting from development

(Describe the effect on the fishery of the developments or changes listed in 6.6.)

For example, changes in land practices associated with grazing, agriculture or forestry may result in increased or decreased runoff or erosion. The use of insecticides in intensive farming or the control of forest insects may harm the fishery. Increased land fertilization may change the water quality of the basin. Road construction may increase fishing intensity on areas already overfished or permit useful exploitation of other areas.
Industrialization may increase pollution problems.

8. Discussion and conclusions

9. Recommendations

(See Dill and Kesteven (1958) for suggestions as to methods of minimizing danger to aquatic stocks and gaining the best results from changed environmental conditions.)

10. Summary

11. References
    11.1 Literature cited and/or used for the survey
    11.2 Maps
    11.3 Plans

12. Appendixes (supporting data, maps, photographs, diagrams, tables, special studies, etc.)

1.2 RECORDS AND REPORTS

1.2.1 **Records**

We divide the records of expeditions into three main groups. Firstly, those of the expedition as a whole, comprising the diary of the technical staff and the cruise and station log (of a ship); secondly, the records of the primary operations; thirdly, the records of the secondary operations.

Forms are necessary and useful in this kind of work, where so much is routine, in that they systematize the recording operation, and to some extent simplify it.

A well-designed form has certain general characteristics conforming to a number of criteria.

First, it provides space for recording all the information required concerning the operation for which it is designed.

Second, it does not call for the recording of information that is better recorded in connection with some other operation, and it provides for easy cross-reference between sets of records.

Third, in the case of forms relating to techniques, the design permits the entry of information in the sequence in which the operations of the techniques are carried out.

Fourth, it does not require or invite repetition of information common to a number of items, nor is space wasted by repetition; for example, if many operations are carried out at a station, the station number should be shown once as common to all these operations and not repeated for each, and if possible there should be a separate sheet (or group of sheets) for each station with appropriate space for station identification. A common error in form design is to provide a column for information that is entered only once, and for which, therefore, a single line, or box would be sufficient.

Fifth, in the case of a form for data that will be treated statistically, as far as possible it should serve the purposes of the statistical operatives as well as of the field worker.

Sixth, it is of size, shape and material suitable for the conditions under which it will be used, and for the convenience of the user.

Seventh, it conforms as far as possible to statisticians' norms concerning size of spaces, width of column, and layout.

Finally, it is of utmost importance that each set of records (and in fact, that each sheet) should be self-contained and completely clear, and must be usable without reliance on memory. Each form should be designed to achieve this.

The basic scientific record of an expedition is the diary, an hour-by-hour and day-by-day record of the activities and observations of the scientific staff of the expedition. Note is kept in the diary of general movements of the expedition, stations occupied (with their position), operations performed showing the objects (kind and number) to which various techniques have been applied, and any general observations made by the scientific staff (e.g., of whales or birds seen, particular meteorological and hydrographic phenomena). On cruises the scientific diary is supplemented, and in some respects checked by the cruise log, which records all movements in detail, shows stations occupied and notes the operations performed at each, and records information on the management of the expedition.

In this Section we deal with only the cruise and station log, leaving to appropriate other Sections a discussion of the specialized records, to be kept for particular sets of operations.

Form 1. - Cruise and station log

(*a*) *Vessel*..............................

(*b*) *Cruise No.*......................

1	2	3	4		5	6						7	8
Date	Hour	Hour	Position		No. of	Logs filled						Gear	Remarks and special observations (Fish schools, birds, detritus and plankton, discoloration of water, notes about fishing fleet, etc.)
	start	finish	Lat.	Long	Station	6.1	6.2	6.3	6.4	6.5	6.6	overboard	
			4.1	4.2		Met. log	Orig. Oceanogr. log	Plankton log	Fishing log		Photos		

Notes on Form 1. Cruise and station log [5]

This log is a master record of the cruise. It should be kept by the navigation officer assisted by the scientific watch, in duplicate, by means of a carbon copy. Basically it lists and locates the stations and records the kinds of operations carried out at each by showing in columns 6.1 to 6.6 the scientific logs completed.

4. For "underway" stations, give position at commencement of the scientific operation for which the station is taken.

6. Indicate with x the logs in which notes are entered for each position and/or station.

7. Record the items of gear used.

8. Indicate the change of course and observations on birds, fish schools and pleuston sighted. (See instructions in Section 2.) For longer descriptions use the reverse side of the log, numbering every note so that it is clear to which observation, station and position the remark belongs.

It is necessary to emphasize the importance of careful and systematic storage of all field records and it is further to be advocated that each institution should maintain a field records unit in which all records are registered and stored when not in use. The field records unit should keep a register of movements of each log diary and set of papers. Such a system has many advantages over the system in which each officer responsible for the original observations retains the records of them as his personal property.

Many laboratories have their own card systems for the recording of data. Such card systems exist also regionally. An example is the mechanized punch card system of hydrographical data of the International Council for the Exploration of the Sea and the BT data cards of the U.S. Navy Hydrographic Office, etc.

The following points on the keeping of records and reports are generally valid in a wide variety of conditions:

1. No original data are to be disposed of until all possible need for reference to the data has ceased to exist.

2. Do not deviate from a prescribed schedule without real justification. Consistency is very important in both the obtaining and recording of field data. When doubts arise as to correct procedure consult your immediate supervisor.

---

[5] In these notes the numbers refer to the column of the table to which the note relates; letters refer to entries above the columns.

3. Field data are to be entered in the books in the prescribed manner the same day that they are recorded in the field.

4. A diary is to be kept by all members of the fish research section.

5. In some cases, estimates of one kind or another are in order. When figures represent an estimation rather than an actual count or measurement, place an E after the figures.

6. New projects. When a new project is to be undertaken, the following procedure will apply:

(*a*) A complete project outline will be submitted to the appropriate authority or office for approval.

(*b*) The individual to whom the project is assigned should receive pertinent data on objectives, personnel, equipment and funds available for the project.

(*c*) The person to whom the project is assigned should take whatever time is necessary to review the literature on the subject and examine thoroughly, in the field, the area to be studied.

(*d*) The person to whom the project is assigned shall then be responsible for carrying out the project and shall keep the supervisor advised of progress.

1.2.2 **Writing of reports and presentation of data**

1.2.2.1 Writing of reports

Reports required will fall into one of the following classifications: (1) data report; (2) activity report; (3) special report; (4) annual progress report; (5) completion report; (6) report for publication.

Reports are frequently required from fish research personnel on unscheduled work. Investigations of diseased fish, brief studies of lakes or streams, and summaries of special data for administrative use are examples of reports that would fall in the special report category. The content of special reports should follow any convenient and logical form that best fits the individual situation.

Reports of trips should be written as soon as possible, while details are still fresh in the memory. A preliminary expedition report should be assembled for immediate discussion, and might take the following form.

A. Expedition plan

1. Copy of original plan.
2. Statement of departures from plan and reasons for these.

B. Work performed.

1. Summary tabulation of:

(*a*) area(s) worked
(*b*) station occupied
(*c*) operations carried out
(*d*) material collected

2. Statement of records kept (log identification numbers, etc.) and of where these are lodged.

C. Principal results, so far as these appear prior to detailed laboratory working up.

The preliminary results of investigations are more valuable if they are made available for distribution as soon as possible, especially if they are not only in the form of rough data but also contain comments and tentative conclusions.

Such a preliminary report would be only a working document for record and discussion purposes and for internal use. It should be followed by a report developed after material has been worked up, tabulated and placed on maps and diagrams. This second report, which can be for wider circulation, should be a self-contained account of the expedition, and preparation of it should not be made contingent in any way on completion of the research program of which the expedition was part. It should show:

Objectives
Area of operations and itinerary
Staff
Equipment and methods
Work done (stations occupied, operations carried out)
Materials collected
Results obtained

The following general guiding principles for the writing of reports are stressed at research institutions. Where applicable, these principles should be adhered to in preparing reports.

1. The introduction should make a favorable impression on the reader, leading him to read at least the summary.

2. The summary should be written in language meaningful to the top executive who may read it.

3. The summary should mention all important parts of the work, and every statement in the summary should be developed at greater length in the body of the report.

4. The introduction should tell (*a*) why the work was done, (*b*) when the work was done, (*c*) what the reader needs to know in order to understand the body of the report.

5. The various subdivisions of the body of the report should be arranged in logical order, and their relationship to one another and the body of the report made clear throughout.

6. The report should be positive in attitude, impersonal in style, and professionally dignified in manner.

7. The report should be made readable, by using short sentences, active verbs, and simple words in preference to complex.

8. The grammar should be acceptable without being artificial or stiff.

9. There should be just enough words, neither too few nor too many, with every word accurate and well chosen.

10. All tables and graphs should be arranged so that they may be reproduced without confusion and delay and the reader may understand them without special help.

1.2.2.2 Presentation of data

It is desirable to present as much data as possible in visual form (graphs, profiles, maps). The choice of map scale and projection depends on the subject and area of interest. In marine work usually mercator projections are used. In some work it is necessary to use not only the geographical positions, but in addition the Marsden squares.

This system was devised by Marsden in 1831. He divided a Mercator chart of the world into rectangles of 10° latitude by 10° longitude. Each rectangle is arbitrarily numbered and is again subdivided into 100 one-degree squares which are numbered from 00 to 99 so that, given the position of the squares, the first figure of the subsquare denotes the latitude and the second figure the longitude. (See Figure 1.) The one-degree squares are indicated in the accompanying diagram by dotted lines, which shows also how each Marsden square may be subdivided into 25 two-degree squares (light continuous lines) or 4 five-degree squares (bold continuous lines).

In quoting a reference number the digits standing for the Marsden square number are separated from those indicating a subdivision by a full point. If it is necessary to distinguish in the notation between one-degree and two-degree squares, it is suggested that in the latter case a hyphen be used instead of a point to separate the two parts of the number, thus: 62-06.

Before the expedition starts it is desirable to prepare scaled blank profiles for use on board and for the working up of data. As an example of profile scales, the following relation could be given:

(*a*) Surface profile 0 to 300 m

Scale: 10 sea miles = 2 mm

10 m depth = 4 mm

It is advisable to present the marine environmental data in data reports as soon as possible. The following set of data may serve as an example:

1. Profiles

Surface profiles:

(*a*) T °C (and thermocline)
S °/oo

(*b*) O_2
PO_4-P

(*c*) Chlorophyll μg/m³
Zooplankton biomass mg/m³

Surface to bottom profile:

(*a*) T °C
S °/oo

(*b*) O_2
PO_4-P

2. Tabulated data

(*a*) Tabulated hydrographical data
(*b*) Sighting of fish schools, birds, etc.
(*c*) Catches with fishing gear
(*d*) Benthos data

3. Track charts with notations of stations, surface temperatures, convergences, relative values of surface turbidity, etc.

Several biological data can be expressed in various ways. Figure 2 illustrates the effects of the different representation.

More detailed information on representation and working up of collected data will be found in other FAO publications and documents.

1.2.3 **Shipboard photography**

To give detailed instructions for photography would require a separate textbook. Reference is therefore made only to a few points concerning the use of photography at sea. It may be said that it is good practice to be liberal in the use of the camera during an expedition, since this may provide valuable records. Routine operations do not normally need to be

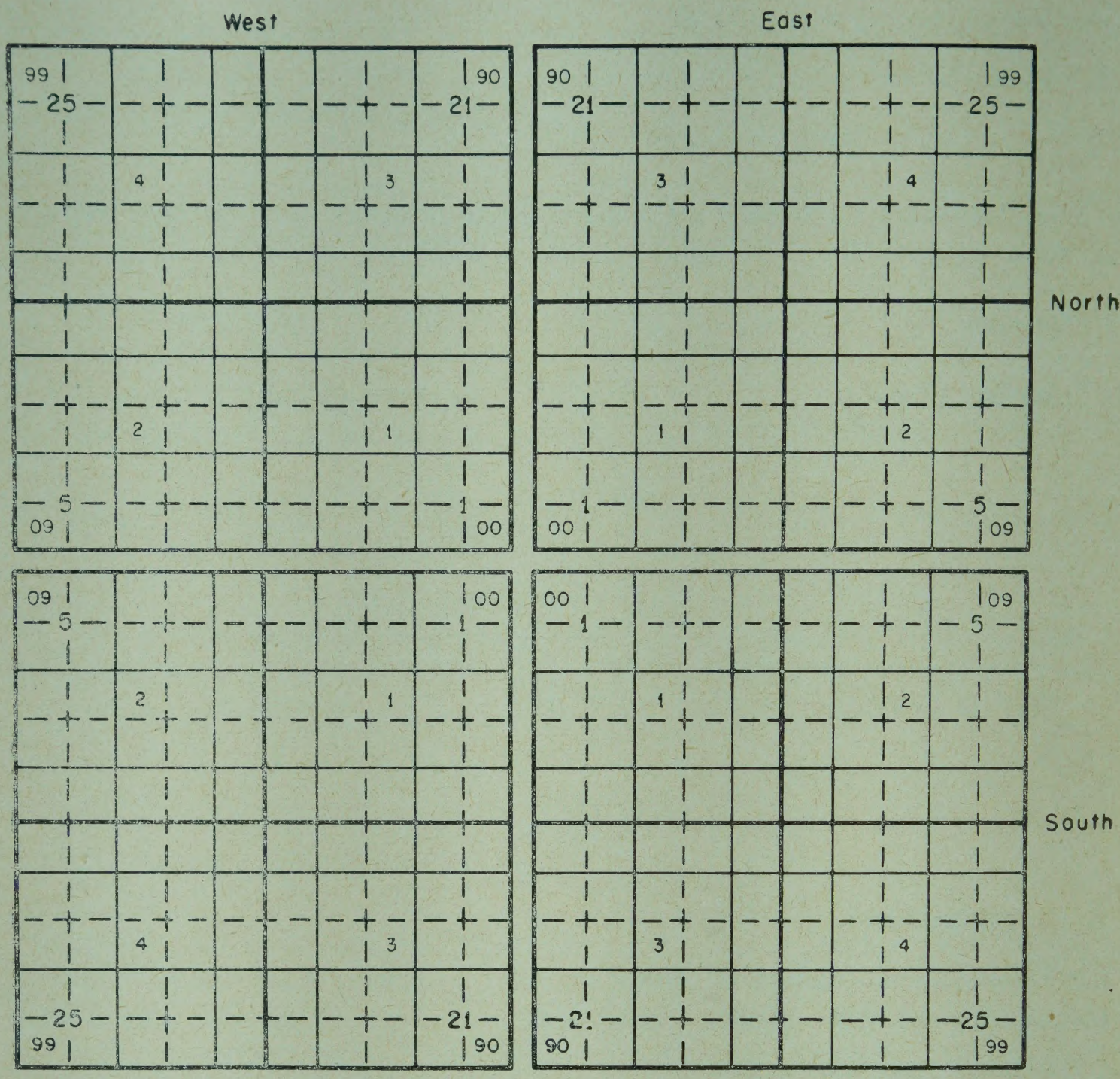

FIGURE 1. - Numbering of Marsden squares

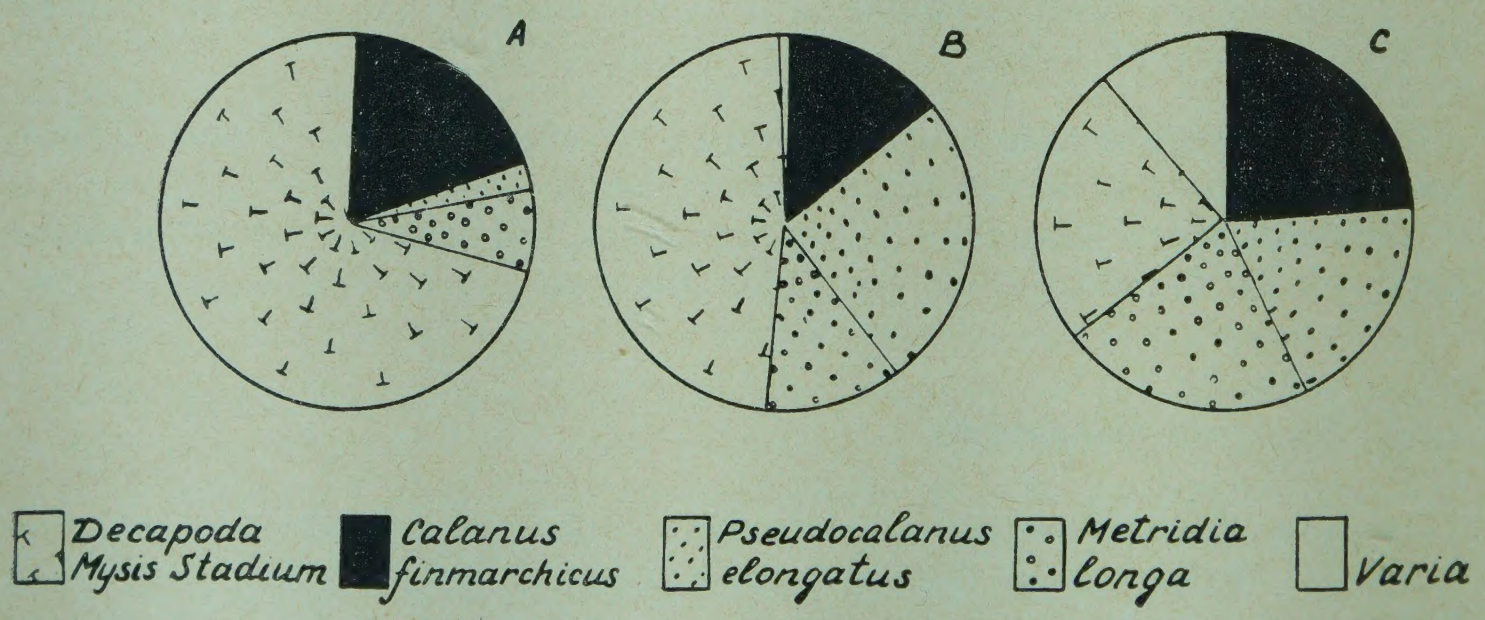

FIGURE 2. - The importance of different food components in the nutrition of the herring (from the White Sea) expressed in: A - weight, B - number of organisms, and C - frequency of occurrence (after Bogorov)

documented in this way, but special operations and particular phenomena such as discoloration of the sea, mass mortalities (most of which require color film) are most effectively reported with photographic evidence. Special studies, such as the schooling habits of pelagic fish, benefit greatly from a photographic record.

Photographs of matters of interest should always be taken at the first opportunity, not postponed in hope of the most favorable circumstances: they may not come. Whenever possible a photographic plan should be prepared beforehand; this is indispensable for a cinematographic record of operations. Special precautions must be taken to protect photographic equipment against the effects of salt spray. Exposed metal parts should be given a light coat of thin oil.

Exposures at sea generally require special care in light measuring. Reference should be made to photographic manuals for rules on this and on such matters as choice of film.

1.2.4 Selective list of manuals and textbooks in fisheries, oceanography and limnology

(*Note*: For specific detailed references see end of corresponding Sections)

AMERICAN PUBLIC HEALTH ASSOCIATION. 1960 *Standard methods for the examination of water and wastewater, including bottom sediments and sludges*. 11th ed. New York. 626 p.

BARNES, H. 1959 *Apparatus and methods of oceanography*. Part I. *Chemical*. London, Allen and Unwin. 341 p.

BOUDAREL, N. 1948 *Les richesses de la mer: technologie biologique et océanographique*. Paris, Lechevalier. 549 p.

BÜCKMANN, A. 1929 Die Methodik fischereibiologischer Untersuchungen an Meeresfischen. 194 p. *Abderhalden, Handbuch der biologischen Arbeitsmethoden*, 9 (6,1).

CAPURRO, L. 1959 *Química del agua de mar*. Buenos Aires, Servicio de Hidrografía Naval. 140 p.

DAVIS, C.C. 1955 *The marine and freshwater plankton*. East Lansing, Michigan State University Press. 562 p.

DE BUEN, F. 1952 *Las familias de peces de importancia económica*. Santiago de Chile, FAO. 311 p.

DEMEL, K. & KULIKOWSKI, J. 1955 *Oceanografia rybacka*. Warszawa, Panstwowe Wydawnictwo Naukowe. 283 p.

DIETRICH, G. & KALLE, K. 1957 *Allgemeine Meereskunde*. Berlin, Borntraeger. 492 p.

FRANCIS-BOEUF, C. 1947 *Les océans*. Paris, Presses universitaires de France. 128 p.

GRIMPE, G. 1925-44 *Die Tierwelt der Nord- und Ostsee*. Leipzig, Akademische Verlags-Gesellschaft. 12 vols.

HUTCHINSON, G. E. *A treatise on limnology*. New York, Wiley. 1015 p.
1957
KUENEN, P. H. *Marine geology*. New York, Wiley. 568 p.
1950
LAFOND, N. C. *Processing oceanographic data*. Washington, D.C., U.S.
1951 Navy Hydrographic Office. 114 p. H.O. Pub. 614.
LAGLER, K. F. *Freshwater fishery biology*. Dubuque, Iowa, Brown. 421 p.
1956
LÜBBERT, H., EHRENBAUM, E. & WILLER, A., eds. *Handbuch der Seefischerei*
1928-58 *Nordeuropas*. Stuttgart, Schweizerbart. 22 vols.
MARR, J. C. *Biología pesquera marina*. Santiago de Chile, FAO. 143 p.
1952
MARTÍNEZ-HIDALGO Y TERÁN, J. M., ed. *Enciclopedia general del mar*. Ma-
1957-58 drid, Garriga. 6 vols.
NAINTRÉ, L. *Traité de la pêche en mer*. Paris, Crespin-Leblond. 349 p.
1960
PARDO, L. *Acuicultura continental*. Barcelona, Salvat. 443 p.
1951
ROMANOVSKY, V. *et al. La mer*. Paris, Larousse. 503 p.
1953
ROUCH, J.A.P. *Les océans*. Paris, Colin. 216 p.
1957
ROUNSEFELL, G. A. & EVERHART, W. H. *Fishery science: its methods and*
1953 *applications*. New York, Wiley. 444 p.
RUTTNER, F. *Grundriss der Limnologie* (*Hydrobiologie des Süsswassers*).
1962 3. neubearb. und erweiterte Aufl. Berlin, Gruyter. 332 p.
SCHOTT, G. *Geographie des Indischen und Stillen Ozeans*. Hamburg, Boysen.
1935 413 p., charts.
SCHOTT, G. *Geographie des Atlantischen Ozeans*. Hamburg, Boysen. 438 p.,
1942 charts.
STRICKLAND, J.D.H. & PARSONS, T. R. *A manual of sea water analysis*.
1961 Ottawa, Fisheries Research Board of Canada. 185 p. Bulletin 125.
SVERDRUP, H. U., JOHNSON M. W., & FLEMING, R. H. *The oceans: their*
1949 *physics, chemistry and general biology*. New York, Prentice-Hall.
1087 p.
THIENEMANN, A., ed. *Die Binnengewässer Mitteleuropas*. Stuttgart, Schweizer-
1925 bart. 255 p. Die Binnengewässer, Bd. 1.
U. S. NAVY HYDROGRAPHIC OFFICE. *Instruction manual for oceanographic*
1955 *observations*. 2nd ed. Washington, D.C. 210 p. H.O. Pub. No. 607.
VIBERT, R. & LAGLER, K. F. *Pêches continentales: biologie et aménagement*.
1961 Paris, Dunod. 720 p.
WELCH, P. S. *Limnology*. New York, McGraw-Hill. 471 p.
1935
YAÑEZ, P. *Introducción a la bibliografía pesquera*. Santiago de Chile, FAO.
1952 89 p.
ZOBELL, C. E. *Marine microbiology*. Waltham, Mass., Chronica Botanica.
1946 240 p.

Price: $0.50 or 2s 6d 15615/8.65/E/1/3800